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ABSTRACT

The study compared the effects of two instructional strategies for teaching the programming language, Logo, on the problem solving skills of third graders. The two strategies are the guided discovery approach, a student-directed learning environment with the teacher as a facilitator, and the direct instruction approach, with specific teacher-directed activities being used to teach direct transfer of problem solving skills. The relationship of two cognitive styles--field dependence and field independence--and the development of problem solving skills through the two different teaching methods were analyzed. The subjects were 49 third-grade students in three existing classrooms. Ten weeks of instruction in Logo was given to two treatment groups, with a third group receiving no instruction. Data analysis showed that Logo instruction does improve problem solving skills, with both instructional methods improving skills at the same rate. The degree of students' field dependence did not effect their ability to gain problem solving skills by either method. The text is supplemented by six tables and appendixes provide supporting materials. (76 references)
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THE EFFECT OF LOGO INSTRUCTION METHOD ON PROBLEM SOLVING SKILLS AND THE RELATIONSHIP OF COGNITIVE STYLE ON PROBLEM SOLVING SKILLS LEARNED THROUGH LOGO INSTRUCTION

A Thesis

Submitted

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

Debra Bruene Roach

University of Northern Iowa

July 1988

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Abstract

The study compared the effectiveness of two instructional strategies for teaching the programming language, Logo, on third graders' problem solving skills. The guided discovery approach, is a student directed learning evironment with the teacher as a facilitator. The other approach teaches Logo through direct instruction. Specific teacher directed activities are used to teach direct transfer of problem solving skills.

The relationship of the cognitive styles, Field Independent and Field Dependent to the ability to develop problem solving skills through Logo instruction was researched. The relationship between field dependency scores and development of problem solving skills through two different methods was analyzed.

The subjects were forty-nine third graders, in three existing classroom sections. Each group was pretested with the Children's Embedded Figure Test to determine field dependency. The Purdue Elementary Problem Solving Inventory was the pretest measure of problem solving skills.

Ten weeks of instruction in Logo was given to two treatment groups. The control group received no Logo instruction. At the conclusion of the treatment, all three groups were posttested with the Purdue Elementary Problem Solving Inventory.

Data analysis showed that Logo instruction does improve problem solving skills. Both instructional methods improved the skills at the same rate. The degree of students' field dependency did not effect their ability to gain problem solving skills by either method.

TABLE OF CONTENTS

Chapter Page

List of Tables iv

I INTRODUCTION 1
Logo Background 1
Discovery Versus Direct Instruction of Logo 3
Problem Solving Background 4
Field Independence/Dependence Background 6
Hypotheses 8
Limitations 8
Definitions 9

II REVIEW OF LITERATURE 12
Logo Instruction 12
Problem Solving 24
Field Dependence/Independence 27

III METHOD 32
Subjects 32
Design 33
Procedures 34
Materials 37
Statistical Analysis 39

IV RESULTS 41
Analysis of Data 41

V SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 48
Summary 48
Conclusions 49
Recommendations 52

REFERENCES 55

APPENDIX A: PERMISSION SLIP 61

APPENDIX B: LESSON LOGS 62

APPENDIX C: SAMPLE ACTIVITY SHEETS 65

APPENDIX D: SCHEDULE 70

LIST OF TABLES

Table Page

1: Field Dependent/Independent Characteristics 10

2: Table of Groups' Mean Scores 33

3: Summary Table of the Means and Standard Deviation of PEPSI Score and CEFT of the Groups 42

4: Summary Table of Two-Tailed T-test on Posttest of PEPSI 43

5: Summary Table of Pearson Correlation Matrix 45

6: Summary Table of Analysis of Variation of Posttest PEPSI by CEFT, Treatment, and Gender 47

CHAPTER I

Introduction

A summary of research and literaure concerning Logo presents views both supportive and critical. The question of guided discovery versus direct instruction methods for Logo and the level of teacher intervention was researched. Transfer of generalizable problem solving skills to new situations was assessed.

The perceptual style of field dependence or field independence was examined to determine any relationship between ability to develop problem solving skills through Logo programming and transfer them to real-life situations. The relationship of field dependence/independence to the ability to learn problem solving skills in a guided discovery method versus a direct method of Logo instruction was examined.

Logo Background

In the early 1960's, Seymour Papert and the Logo group in the Artificial Intelligence Lab at the Massachusettes Institute of Technology began work on a list processing language called Logo (Green & Jaeger, 1983; Watt, 1985; Papert, 1980a). The language was designed to have a low threshold and no ceiling. A low threshold allows children access to the language easily. No ceiling provides challenges to students into higher levels of programming. This excited educators and as microcomputers became accessible in schools, Logo began appearing in many classrooms. Logo columns in

computer education journals reinforced the introduction of Logo into classrooms.

Logo is similar to other programming languages with interactive capabilities. The turtle graphics mode of Logo became popular in many schools, due to the user friendly visual and text feedback. The turtle is a triangular cursor that is programmed to draw using abstract symbols to complete familiar concrete tasks such as drawing a square or a house. This language was designed to develop thinking skills with young students as they write, edit, and debug programs that cause the turtle to draw on the screen. Logo is also recursive which allows procedures to be subprocedures of itself.

Like other languages, Logo extends to higher levels of programming, using variables, symbols to name unknown entities. The language is extensible which allows user defined procedures to look and act like primitive commands. The turtle can be taught to draw "house" however the child defines it. The structure of Logo is designed to build complex procedures from small ones, a concept important in the process of general problem solving. Papert calls this "mind sized bytes" (1980a, p. 17).

The claim that Logo instruction increases and fosters students' problem solving abilities is addressed in this study. Studies have shown that Logo programming instruction improves problem solving skills directly related to Logo but not necessarily to transferrable problem solving skills (Tetenbaum & Mulkeen, 1984; Pea & Kurkland, 1984; Pogrow, 1987). Pogrow called for a strong

linkage of concepts across computer environments for more transferrable learning to occur.

Controversy on Logo research has centered around the appropriateness of research itself. Research pro and con has been rejected by Papert as "technocentric thinking" (Papert, 1987, p. 23). He said researchers must look at the big picture, not just bits and pieces of thinking skills. Emphasizing the total potential of Logo, he posed the question, "What is THE effect of THE computer on cognitive development?" (Papert, 1987, p. 23). Researchers offered as a rebuttal that they are trying to find out under what conditons does Logo have certain effects. They found Papert's claims to be vague and stated that the claims must be recast before they can be scientifically tested (Walker, 1987; Becker, 1987; Pea, 1987).

Discovery Versus Direct Instruction of Logo

The method of Logo instruction has been the focus of much research since Logo was introduced. Supporters of Logo as a method to teach problem solving skills claim that the researchers have taken the discovery learning mode too literally (Papert, 1986; Watt & Watt, 1986; Leron, 1985). The guided discovery method now advocated by supporters involves teacher questioning, guidance and facilitation. The guided discovery method of this study was designed to promote plannning, prediction, explanation, and reflection on learning with teacher guidance.

The discovery method of instruction used in this study is designed to reflect Papert's ideas of discovery. The discovery method of instruction is not used as much as the direct method of

instruction in schools today. Teachers have been trained in the more time efficient method of direct instruction. With students and teachers both more accustomed to the direct method, the discovery method of learning may inhibit learning, merely by virtue of its uniqueness. Teachers and students may be less used to the discovery method and this may be reflected in the study.

The direct instruction method employed in this study was based on the theory that problem solving strategies should be directly taught in order for transfer of skills to occur (Dyerson, 1980; Picus, Sachse, & Smith, 1983; Glenn & Ellis, 1982; Feldhusen & Treffinger, 1977). Students in this method of instruction were taught general problem solving strategies within the Logo environment. The generalizable problem solving skills taught in direct instruction of this study were designed to transfer to other problem situations.

Problem Solving Background

Problem solving suggests an ability to perceive a problem, approach alternatives systematically, and find and test solutions quickly and efficiently. Problem solving consists of a collection of subskills that will be necessary for students to function in modern society (Feldhusen & Treffinger, 1977; Picus, Sachse, & Smith, 1983; Eiser, 1986).

Problem solving has been described as a complex operation requiring divergent thinking ability, creativity, and school achievement (Guilford & Hoepfner, 1971; Houtz & Speedie, 1978). It involves the processes of judgement, inquiry, and concept formation.

Subskills of problem solving most targeted by contemporary computer software publishers include: recognizing patterns, breaking a task into parts, trial and error experimentation, predicting outcomes, and drawing conclusions from data (Eiser, 1986).

Using computers and programming to encourage problem solving skills that transfer across subjects has developed as more technology is available to classroom teachers. Helping students monitor their own thinking to draw conclusions has evolved as a new research area.

For the purpose of this study, twelve specific behaviors defined the problem solving process (Feldhusen, Houtz, & Ringenbach, 1972). The set of skills tested in the Purdue Elementary Problem Solving Inventory (Feldhusen, Houtz, & Ringenbach, 1972) include: (a) sensing that a problem exists, (b) defining the problem, (c) clarifying the goals, (d) asking questions, (e) guessing causes, (f) judging if more information is needed, (g) noticing relevant details, (h) using familiar objects in unfamiliar ways, (i) seeing implications, (j) solving single solution problems, (k) solving multiple solution problems, and (l) verifying solutions.

A question that emerged from a study of problem solving skills (Glenn & Ellis, 1982) called for research on effective methods of teaching problem solving. Their work with direct and indirect methods of teaching problem solving has helped in planning this study of Logo as a method to teach problem solving.

Methods of teaching problem solving through Logo were researched in this study. The effectiveness of these skills taught by a direct approach or by a guided discovery approach were assesed for transfer to real-life problems.

Field Independence/Dependence Background

A third component of this study was the relationship of cognitive style to the ability to learn and transfer problem solving skills. The perceptual style of field dependence/independence is the relative ability to break up an organized visual field in order to keep a part separate from the background field. Students fall on a continuum from field dependent to field independent. The field dependent student follows the organization of a visual field presented while the field independent student can override an organized field and break it into smaller pieces (Witkin, Moore, Goodenough, & Cox, 1977).

The research of the cognitive style relationship to problem solving skills gained through Logo instruction is minimal. The data analyzed in this study can be used in planning and implementing Logo instruction to achieve the best possible results for specific populations.

This study researched the relationship of students' underlying perceptual style to their ability to master problem solving skills and to transfer them to new situations. The visual nature of Logo Turtle Graphics and the "debugging" components in Logo programs, have some relationship to students' problem solving capabilities. A student who is competent at disembedding a hidden figure from an

organized field may be competent at locating problems in a computer program. Disembedding bugs in Logo programs can be compared with identifying the shape within the shape of the Children's Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971). The field independent person is not dominated by the surrounding material and is able to focus on the segmented problem. (Witkin et al., 1971)

The social nature of Logo programminng, involving peer discussion about programs and ways of thinking, is related to field dependency. Field dependent people are more likely to learn from social aspects of the Logo environment (Witkin et al., 1977). The guided discovery class, involving guided student interaction could cause the field dependent students to gain problem solving skills simply by the amount of feedback they receive from interaction.

Field dependent people have difficulty with transfer of isolated problem solving skills to new situations due to their reliance on the provided context (Witkin et al., 1977). This study examined the effect of a guided-discovery approach versus a direct approach on the field dependents' transfer. Direct instruction for transfer of problem solving skills should produce better learning by the field dependent students. In view of the field independent student's ability to impose their own structure, they should learn better from the discovery method of Logo instruction.

Pogrow stated "the constant decontextualizing of these basic concepts is believed to break down the tendency of students to view information strictly in terms of the specific content in which they encounter it. This should increase their ability to integrate new

information into existing networks of ideas in long term memory" (1987, p. 12). This link to field dependent/independent perception may produce insight into the assimilation of problem solving skills.

Hypotheses

The following hypotheses were developed from the review of literature pertaining to Logo instruction. Relationships between Logo method of instruction and field dependence were predicted from the literature concerning field dependence/independence characteristics.

1. Logo instruction will increase students' problem solving skills.

2. Using a direct method of Logo instruction will have a more positive effect on students' general problem solving abilities than a guided discovery method of instruction.

3. A field independent perceptual orientation score will correlate more positively with ability to learn general problem solving through Logo instruction than field dependent orientation.

4. A student with field independent tendencies, taught using the guided discovery method of instruction, will perform better on the measure of problem solving than field dependent taught by the same method.

Limitations

This study involved subjects from a local school district. The limitations of the study are listed as follows:

1. The sample population was from a small midwestern town, with only two minority students.

2. The Logo instruction was only ten weeks in duration.

3. The Purdue Elementary Problem Solving Inventory was the sole measure of change in students' performance from Logo instruction.

Definitions

Guided Discovery Method of Instruction: A student-directed method of learning as prescribed by Seymour Papert, following his interpretation of Piagetian learning (Papert, 1980a).

Direct Method of Instruction: A teacher-directed method of instruction using specific assignments and mastery of concepts before proceeding. Teaching for transfer of problem-solving skills to other situations is included (Bruning, 1984).

Problem Solving: a complex set of skills defined by the Purdue Elementary Problem Solving Inventory (Feldhusen, Houtz, & Ringenbach, 1972) involving: (a) sensing that a problem exists, (b) defining the problem, (c) clarifying the goals, (d) asking questions, (e) guessing causes, (f) judging if more information is needed, (g) noticing relevant details, (h) using familiar objects in unfamiliar ways, (i) seeing implications, (j) solving single solution problems, (k) solving multiple solution problems, and (l) verifying solutions.

Field Dependent: A cognitive style with perception strongly dominated by the overall organization of a surrounding field, and parts of the field are fused (Witkin et al., 1977).

Field Independent: A cognitive style with perception of discrete sections viewed independent of a surrounding field.

The following characteristics describe the opposite poles of field dependent/independent (Table 1) (Witkin et al., 1977; Vaidy, Nasuti, & Rockhill, 1981; Ruble & Nakamura, 1972; Fitzgibbons, Goldberger, & Eagle, 1965; Fleming, Knowlton, Blain, Levie, & Elerian, 1968).

Table 1

Field Dependent/Independent Characteristics

Field Dependent	Field Independent
Use external references	Use internal references
Need structure imposed	Can impose own structure
Socially oriented	Work better independently
Need goals and reinforcement	Set own goals & self-reinforce
Cannot separate discrete items from complex field	Can separate discrete items from complex field

Student: A third grade student at Hudson Elementary, Hudson, Iowa, in the 1987-88 school year.

Logo: The computer programming language designed by Seymour Papert and the M.I.T. Artificial Intelligence Group. Available from Logo Computer Systems, Inc., 121 Mt. Vernon St., Boston, MA.

Turtle Graphics: The graphic mode of the Logo language with a trianglular cursor representing the "turtle." The turtle draws graphics on the monitor as programmed.

CHAPTER II

Review of Literature

Logo Instruction

Papert and his colleagues based Logo upon Swiss psychologist Jean Piaget's concept of constructivism. As the child mentally constructs a microworld that he controls, he moves from the concrete stage of learning to the abstract. The concept is that knowledge is what a child makes, not what goes from the teacher's head to the child's head. Papert believes the making of knowledge takes place as children program with Logo (Reinhold, 1986; Papert, 1980a).

Discovery learning or spontaneous learning is prescribed by Papert in Logo instruction. Papert said, "The less structured approaches will give you greater gains, even on test scores" (Reinhold, 1986, p. 36). He also believes that a child learns what he needs to learn. Papert uses the analogy of an average child learning to speak. There is no curriculum plan or systematic process for learning to speak, but children pick up language from their culture because it is important to their social and emotional life. His belief is that learning about math, computers, and thinking can be equally effective if a child is immersed in a computer and math culture. He talks of "learning without curriculum" and "learning without teaching" in his book, Mindstorms (Papert, 1980a, p. 31).

The original claim was that using a Logo learning environment to teach elementary students would encourage problem solving skills,

mathematical and geometric insight, cognitive and metacognitive skills, creative thinking, and planning skills. In their book, Teachers, Kids, and Logo, Green and Jaeger (1983, p. 1) claimed, "Logo is not only a means by which the user can communicate with a computer, but Logo also provides a medium for discovering successful ways to solve problems." They felt that children will be able to direct their own learning. The authors conceded that "Children are not used to this idea of exercising their own independence and extending it" (p. 2).

Many questions remain concerning the cognitive gains of teaching Logo programming to elementary students. Both supporters and skeptics of Logo seek answers to these questions before valid curriculum decisions can be made:

1. Does Logo increase students' problem-solving skills? (Clements & Gullo, 1984; Pea, 1983, 1987; Tetenbaum & Mulkeen, 1984; Watt, 1979).

2. Which method of Logo instruction promotes the best gain of these skills? (Becker, 1987; Dalton, 1986; Kieren, 1984; Leron, 1985; Nolan & Ryba, 1986; Picus, Sachse, & Smith, 1983).

3. If Logo, in any means of instruction, does indeed enhance students'problem-solving skills, can they be transferred to new situations? (Eiser, 1986; Dalton, 1986; Delclos, Littlefield, & Bransford, 1984; Rieber, 1986; Salomon & Perkins, 1985; Glenn & Ellis, 1982; Walker, 1987).

4. Can students learn to individually set their own educational goals and be responsible for their own learning? (Glenn

& Ellis, 1982; Dyerson, 1980; Leron, 1985; Picus, Sachse, & Smith, 1983; Watt, 1979).

Lawler (1982) described Logo as the union of Piaget's concepts and computer microworlds. He told of a 3 year-old (his daughter) who learned to read by using Logo with little direct instruction. She learned to read by first writing her program commands because she felt the need to know words. He supported Logo in the free learning style of instruction claiming that exploration is appropriate to the person and close to their identity.

Muller (1986), president of the Young People's Logo Association, claimed that Logo is all about learning. His support of Logo is based on the need for children to learn to function in an increasingly technological world. He felt Logo is a tool to learn with, challenging students to think about their thinking, and to function in a technological society.

In studying the effects of Logo on children, Rieber (1986) found that in two groups of 2nd graders, the Logo group showed significant change in scores on a problem solving measure and geometric pencil/paper tests. His results support Papert's view that successful programming interaction encourages problem solving strategies. It is interesting to note that the researcher adjusted delivery methods during the study from discovery to more structured.

Clements and Gullo (1984) conducted research that supports learning with Logo, using guided discovery and teacher directed instruction. They claimed that learning programming is complex and requires direct guidance. A study of first graders showed the Logo

group performed higher on a measure of creative thinking after 3 months of Logo instruction than a group receiving no Logo instruction. The Logo group also tested better on a task to determine whether directions were missing. Clements has conducted several studies evaluating cognitive gains with Logo, most of the studies implemented direct teacher intervention.

Critical Literature

Pea (1983) has conducted extensive research using Logo, supporting the view that Logo does not influence problem solving skills. His work with colleagues at the Bank Street College of Education casts doubts on Logo in the Piagetian learning mode, suggested by Papert. Pea (1983) stated that qualitative research is necessary not anecdotal histories and intuitive attitudes. He said Papert's claim that Logo will stand alone is invalid, and the skills in problem solving need to be directly taught. He disagreed with the belief that a rigorous mental discipline (such as programming) will lead naturally to transfer of general thinking skills.

Pea and Kurland (1984) focused specifically on the planning skills, a sub-skill of problem solving, thought to be gained by teaching Logo programming to students, in a discovery learning environment. They conducted two in-depth controlled experiments with 2nd and 4th graders on transferring planning skills from the Logo environment to a real-life task of efficiently scheduling chores in a classroom. A pretest and posttest required the students to explain the shortest, most efficient way to execute the chores in a hypothetical classroom. If the students could think of a shorter

plan, they then revised it. Video tapes were coded to determine plan revision characteristics. The results showed that students reorganized their plans into more efficient paths whether or not they had programmed with Logo. After a one year exposure (30 hours of programming) to Logo, there was not a measurable influence on planning abilities of students.

Pea and Kurland's second study (1984) was also a year-long exposure to the Logo environment. The second year the same teachers took a more direct role in instruction. The pretest was the same as in the previous study, with students planning chore scheduling in a classroom. A computerized procedure was adapted for the posttest. The program asked students to schedule a robot's path doing the same classroom chores. The computer program gave students feedback similar to Logo feedback. The four types of feedback available were: (a) a read out of time involved to carry out an action, (b) a graphics image of the classroom so the student could see the plan being executed, (c) a step by step readout of each move the student planned and the time it took to carry it out, and (d) a hard copy of the student's plan.

Pea and Kurland (1984) compared the programming students to the non-programmers. They predicted the programmers would have significantly better skills than the non-Logo programmers. If the Logo instruction had improved their skills, they:

1. would be better planners overall, therefore the total time the robot would take to complete the tasks would be less.

2. make better use of feedback so they should ask to review their plans more and see a checklist of remaining chores to be done.

3. should spend more time thinking and planing so there should be more and longer pauses in their plans.

4. should attempt to debug existing plans, revise, and improve rather than start over. Therefore, their revised plans would resemble previous plans.

Pea and Kurland's (1984) study showed "the Logo programming groups clearly did not use the cognitive abilities alleged to be developed in Logo in these tasks designed to tap them" (p. 43). They cite three possible reasons for these results.

First, there may be a problem with the Logo environment as a vehicle for learning these cognitive skills. Second, the discovery learning method may not be sufficient for developing planning skills. Finally, there might not have been enough time involved in Logo instruction to make a difference in students' abilities to plan (although 30 hours is typical of most schools using Logo).

Pea's concerns with Logo are based on the Logo environment's lack of curriculum. Teachers cannot be expected to spontaneously create lessons about thinking skills any more than students can be expected to develop thinking skills from self-directed Logo projects. He called for direct teaching of problem solving skills rather than inducing them from spontaneous discovery learning in Logo programming.

Tetenbaum and Mulkeen (1984) called for a moratorium of Logo used as a problem solving model. They noted that schools,

uncharacteristically, are jumping full force into computer education. The presssures from parents, claims that computers will facilitate problem solving skills, and hopes that computers will succeed where teachers have failed (to teach high level cognitive skills) collectively lead school systems to leap before they look.

Tetenbaum and Mulkeen (1984) cited four similarities between computer use and problem-solving: (a) specific directions (b) goal-oriented behavior (c) sub-goal decompositon and (d) means/end analysis. The two dissimiliarities they listed are: (a) computers have good and fast access to information while humans do not and (b) computers execute a routine until they are done while humans tire or become distracted.

There is no empirical research to support the idea that the similarities outweigh the dissimiliarities. Tetenbaum and Mulkeen (1984) argued that two things must happen before problem solving skills can be transferred from one task to another. First, a process in task one must be identical to a process in task two. Second, transfer requires that the learner know skills not just the content. They suggested that there may be more efficient ways of teaching problem solving than through Logo instruction.

A study done at George Peabody College for Teachers analyzed the method of instruction for teaching thinking through Logo. The study (Delclos, Littlefield, & Bransford, 1984) used three methods of teaching Logo to 5th graders. At one pole was Papert's vision of discovery learning with Logo and at the opposite pole was a very structured teacher-directed delivery. A third style, termed

mediational, called for the teacher to give individual help, review, ask for student examples, discuss problems and solutions, and relate old tasks to new.

The structured direct method of instruction was better than discovery for mastering program-specific skills (Delclos et al., 1984) The mediational style provided the best results on a broad range of academic abilities. Their preliminary data suggested that students taught using discovery learning could perform adequately on a test of command mastery but could not predict command executions. They noted two problems inherent in the discovery method of instruction. One is that exploration without direction tends to be impulsive and random. Students fail to apply skills learned from programming to new problems unless instructors model strategies. Students who were able to set their own goals fared better than did others under the discovery learning method.

In a pre-experimental study Roach (1987) assessed the gains in problem solving scores with three Logo classes, taught using discovery learning. Three classes of EZ Logo (Minnesota Educational Computing Corporation), Beginning Logo (Logo Computer Systems Incorporated), and Advanced Logo were pretested and posttested, with instruments designed by the instructor to test: Creativity, Debugging, Coding, Exploration, Planning and Analysis, and Prediction. The instruments were designed following the six problem solving skills as described by Horton and Ryba (1986). After 25 hours of discovery learning with Logo environment, the statistical

analysis of data for thirty students showed no significant gains in problem solving scores on tests measuring the six skills.

The merits of the indirect or discovery learning method of instruction to teach problem solving skills have been examined in a pilot study by Glenn and Ellis (1982). A control experiment used direct versus indirect methods of instruction on the problem solving skills of 3rd and 4th graders. One group was taught using a direct method, where the teacher presented steps in a problem solving model. After learning the model, the students practiced these steps in a real life situation. Specific teacher feedback, referring students to the appropriate steps, guided them through the practice.

The other group, the discovery method, was guided through questions, to analyze a real-life problem. Students analyzed the problem and received teacher feedback, but they did not refer to a specific model or steps. Students were to discover ordered general steps to solve a problem. In a posttest, both groups solved the same real-life problem. Responses were judged to be systematic or random. The results supported the conclusion that direct instruction may be more effective approach for teaching problem solving. The most significant factor in the students' acquisiton of problem solving skills was the method of instruction.

Feldhusen and Treffinger (1977, p. 13) stated that educators "should not be content to wait for creativity and problem solving to occur spontaneously. It will be necessary for you to take some very direct, deliberate action to see that it happens."

Supportive Literature

The rebuttal to the negative research findings came in many forms. Educators who have worked with Logo for several years continue to validate the use of Logo by citing examples of successful student case histories.

Kee Au, Horton, and Ryba (1987) stated conflicting reports result from the wide variation of teaching methods and measurement instruments used. Their research showed that teacher questions and discussions are the key factors in the use of Logo to teach problem solving. Their work at Massey University lends credence to the idea that effective methods of instruction with a process-oriented approach teach general problem solving skills such as planning, analysis, monitoring, and evaluation.

Delclos, Littlefield, and Bransford (1984) explained that Pea's negative results lie in the method of instruction. Three studies done by Pea and the Bank Street College of Education group, used the discovery method of instruction. Delclos et al. (1984) argued that using this method has developed little progress in programming expertise, depth of understanding in programming concepts, and planning with problem solving skills.

A compromise to ease the tension between spontaneous, student-directed Piagetian learning and rigid over-structured instruction was described by Leron (1985) as "quasi-Piagetian learning." This is a more active role for teachers but retains the exploration and non-critical attitude of Piagetian learning. Without direction, students will fall into hacking programming with

lots of trial and error but no planning or review. Leron felt that students don't have the burning curiousity or the need to understand and debug that Papert describes. Many students are content to copy procedures with no curiosity about the procedure.

Leron (1985) posed quasi-Piagetian learning as a plausible compromise between subject-centered approach and learner-centered approach. He stated that care should be taken to avoid falling into an anti-Piagetian style which could be forceful, fixed, and rigid. Students resist this structured programming approach by refusing to see the interface between subprocedures or turtle's position before and after each procedure. The debugging skills that are closely related to problem solving are not normally learned through Piagetian learning alone. Leron called for more research on how Logo is used in the classroom.

Watt and Watt (1986) described the research to date as "leaping over the Logo experience in an attempt to focus on external measures of generalizable skills and behaviors that students might learn through the use of Logo" (p. 55). They claimed that the limitation of studies conducted to date is an unspoken assumption that Logo will serve as a package treatment for effects that can be measured. They also submit that the interpretation of discovery learning has been too literal. Together they plan to develop methods to help teachers sharpen their skills of leading students through an effective path toward real evaluation of all Logo student learning.

Papert (1986) responded to the skeptics of Logo discovery learning by stating that perhaps discovery learning is a bad

definition. He felt that it too often is simply a teacher asking questions to get the answer they perceive as right. He stated a better definition would be to let the child develop in his/her own direction. He currently states that "it is very different from saying children should discover everything they know" (p. 36). The student will ask for information when it is pertinent to his agenda. Papert felt that too much emphasis is placed on what the child knows and not enough on how he relates to that knowledge.

Papert responded to the research findings with (Cox, 1987, p. 3) "I don't care what anybody's tests of cognitive change say--I can see something happening that is more important that those tests. I see children who never thought of themselves as capable of controlling a complex, technological machine realizing that they can, and being very turned on to learning by this." His concern is how the child will think of himself: as a button pusher or a person controlling a machine.

Papert stated (Solomon, 1986, p. 131) that "changes in children's learning are demonstrable not through testing different pieces of curricula but by looking at the whole child and the whole classroom." Papert compared the question "Does Logo work?" to "Does wood produce good houses?" (Papert, 1987, p. 24).

He identified the designer of the instruction and culture involved with Logo instruction as the crucial treatments, not just a package called Logo. As a response to Pea and Kurkland's (1984) study, Papert said, "Pea's negative result is moderately compelling if you believe that Logo is a well defined entity (like drug X) that

either has an effect or does not have an effect. However, the finding as stated has no force whatsoever if you see Logo not as a treatment but as a cultural element--something that can be powerful when it is integrated into a culture but is simply isolated technical knolwedge when it is not" (Papert, 1987, p. 24).

Papert has redefined his idea of discovery learning to clarify what was perhaps misinterpreted. His latest view includes a more general description, saying that some children need a more structured approach. He claims that these childern will still learn through the discovery method. He feels that the cognitive measures say one thing and teachers are voicing another. He says the teachers, who are closest to the children, should be the trusted resource for judging the merits of Logo. He stated that a two-year longitudinal study by Ontario Ministry of Education found that most educators feel that something wonderful is happening with computers in classrooms.

Problem Solving

A growing interest in teaching problem solving skills has evolved since the 1983 release of the National Commission on Excellence in Education report, A Nation At Risk. Although problem solving instruction is not new, theories about what and how problem solving skills should be taught are being continually being defined (Picus, Sachse, & Smith, 1983; Dyerson, 1980). When microcomputers became more available in classrooms, new ways of teaching problem solving were introduced. Research began to evaluate this new vehicle for instruction of problem solving skills

(Pogrow, 1987; Eiser, 1986; Hawkins, Homolsky, & Heidi, 1984; McAllister, 1985; Papert, 1980b; Pea, 1983; Clements, 1983a; Watt, 1979).

Polya (1957) posed four basic steps in problem solving as: (a) understanding the problem, (b) devising a plan to solve the problem, (c) carry out the plan, and (d) evaluate the plan. Polya's basic steps can be broken down even further into the twelve abilities measured by the Purdue Elementary Problem Solving Inventory (Feldhusen, Houtz, & Ringenbach, 1972): (a) sensing that a problem exists, (b) defining the problem, (c) clarifying the goals, (d) asking questions, (e) guessing causes, (f) judging if more information is needed, (g) noticing relevant details, (h) using familiar objects in unfamiliar ways, (i) seeing implications, (j) solving single solution problems, (k) solving multiple solution problems, and (l) verifying solutions.

A synthesis of problem solving research by Picus, Sachse, and Smith (1983) reported consistent findings. There are:

1. Students can learn to be better problem solvers with focused instruction.

2. Direct teaching of problem solving strategies improves skills.

3. A knowledge base in the area involved increases problem solving competence.

4. Transfer of problem solving skills is more likely if strategies are taught with problems similar to ones students will routinely encouter in real life.

5. The most successful problem solving instruction requires attention to student motivation, content knowledge and skills/strategies.

Strategies to aid students in understanding and defining the problem are suggested by Picus et al. (1983). These are: to practice writing and verbalizing what the problem is, to list important data, translate the problem, and to put the problem in visual form. The graphics mode of Logo's turtle geometry serves the purpose of visually stating the problem. Teacher intervention can stimulate students to process the other strategies.

California State University Professor Arthur Costa (1987) warned that educators should not expect quick results in the teaching of problem solving skills. He warns that it often takes a minimum of two years before any significant and enduring change can be observed. He recommended direct teaching of thinking and problem solving as content.

The suggested methods of aiding students to devise plans to solve problems are: trial and error, organized listing, experimentation, simulations, simplification, generalization, deduction, induction, searching for patterns, analogies, and working backwards (Picus et al., 1983). All of these methods have applications in Logo instruction.

Field Dependence/Independence

Cognitive learning style refers to the method of processing information. Witkin and Goodenough's (1981) conception of cognitive style is based on approxiamately thirty-five years of research, which has been collaborated and verified (Heesacker, 1981). Cognitive styles are: (a) concerned with form rather than content, (b) able to cut across boundaries, and (c) stable over time.

Field independence is the tendency to rely primarily and consistently on internal referents to perceive information. Field independent people are more able to separate discrete items in a complex field.

Field dependence is the tendency to rely more on external referents to process information. Field dependent people have more difficulty separating discete items from complex fields. Individual are not classified in one distinct categories but fall on a continuum of varying degrees of strength.

Early research (Witkin, Moore, Goodenough, & Cox, 1977) on these styles began with the Rod and Frame Test (RFT), where subjects place a rod in vertical position within a tiltable frame. The perception of the subject can be manipulated by the rotation of the visual field (the frame) or by the felt position of the subject's body. The field dependent person will position the rod in relation to the frame where the field independent person poisiton the rod in relation to their own body.

Another research test was the Body Adjustment Test (BAT) (Witkin et al., 1977). In this situation the perception of body to upright is determined. The subject sits on a chair in a room that can be tilted, and is asked to put the chair in upright position. The pull of gravity and the visual perception of the room cause the field dependent person to place the chair in coordination with the room orientation. The field independent person will bring his body to upright position according to his internal referents.

The question in both of these tests is the extent to which perception is determined by the surrounding stimuli, either the frame or the room. At one end of the continuum were field independent subjects, who percieved their body as separate from the surroundings. At the other end of the continuum are the field dependent subjects who use the surroundings to percieve position. All subjects did equally well with their eyes closed, emphasising the difference between internal and the external visual reference (Witkin et al., 1977).

A third method of determining field dependence/independence is the Embedded Figures Test (EFT) (Witkin et al., 1977). A subject is shown a simple shape which is then removed. The task is to find that shape within a complex geometric figure. Individuals who locate the shape quickly are field independent and those at the other extreme are field dependent.

In all three situaions the extent to which the surrounding field influences perception is determined. To score highly on these

measures the subject must be field independent. All three tests show consistent results with subjects across the ages and sex.

Field dependence and independence at opposite poles have adaptive value under specific conditions. Some circumstances find the field dependent student at an advantage and others find the field indepdendent at an advantage.

Application with Discovery and Direct Instruction

Discovery learning contains two components that may determine learning dependent on cognitive learning style. The field independent students would excel in the unstructured format of discovery learning due to their ability to impose structure upon the stimulus. Yet the social aspects of discovery learning should foster greater learning from the field dependent student. Studies to both of these effects have been cited. Field dependent students were more likely to learn from social situations (Vaidy, Nasuti, & Rockhill, 1981; Witkin et al., 1977; Ruble & Nakamura, 1972; Fitzgibbons, Goldberger, & Eagle, 1965).

A study by McLeod and Adams (1979) found field independent students achieved most in a discovery oriented instruction. They also found that field dependent students learned best in a direct instruction method.

A study by Fleming et al. (1968) presented subjects with hierarchical ordered lists to memorize. One list had an organization aid built in with description of the hierarchy rationale. The field dependent subjects did much better with the aided list while it made no difference to the field independent

subjects. The ability of the field independent students to impose their own structure on the lists provided them with their own hierarchical structures.

A similar study by Vaidy, Nasuti, and Rockhill (1981) found field independent students more successful at solving mathematical word problems that had no helping questions while those questions greatly improved the field dependent students' performance. This supports the theory that the field independent students were more able to structure and set up problems to be sovled.

Applications with Logo Instruction

The ability to separate discrete parts from the background field directly relates to Logo instruction. The necessity to perform this ability is used in the debugging phase of Logo programming, as students identify the problem area. The ability to separate a portion or "mind-size bytes" (Papert, 1980a, p. 103) from a program to debug it is also a field independent chacteristic. As students fix mistakes in their progams, they hunt for bugs that can be changed. Locating the section of the program responsible for the problem is similar to the searching for a geometric shape within a more complex shape, The Embedded Figures Test (Witkin et al., 1977).

Students use their body to perceive relationships in space or on the monitor. From observation, many students determine the turtle's path by turning their own heads upside down and sideways to internalize the heading of the triangular cursor by playing turtle. The field dependence/independence measures of the rod and frame test

as well as the body adjustment test (Witkin et al., 1977) relate directly with the student's use of their body as an internal referent in solving the problem.

The immediate feedback given to students using Logo will influence their learning. As the turtle draws on the screen and replies to input with text, the success or failure is immediate. A study by Renzi (1974) found that field independent students were not influenced by feedback but the field dependent students did better on posttest if they received feedback.

An important aspect of Logo programming is the testing of hypotheses by watching the turtle execute commands on the screen. The field independent student tends to favor a hypthosis testing approach to learning while the field dependent student will favor a spectator approach (Witkin et al., 1977).

Chapter III

Method

The purpose of this study was to determine the effect of Logo instruction on students' problem solving abilities. The effect of guided discovery instruction versus direct instruction of Logo on a measure of problem solving skills was also examined.

The relationship of the cognitive styles (field dependent and field independent), to the ability to learn generalizable problem solving skills was evaluated. An interrelationship between field dependence/independence orientation and abilty to learn problem solving skills from guided discovery or direct instruction was analyzed.

Subjects

Three sections of third grade students at Hudson Elementary school served as subjects for this study. School board and parental permission was received (Appendix A). Two sections were comprised of 16 students and one of 15. One section was taught Logo using a direct method of instruction, one was taught using a guided discovery method of instruction, and the third served as a control. This researcher was the instructor for both methods. One trained fifth grade student assisted in both groups to help answer questions. He did not take part in specific instruction but served as a reference for students.

The classes had different classroom teachers but similar settings and schedules. Students with low, medium, and high ability

levels had been distributed in the three sections based on students' previous records (Table 2). The groups were compared by mean: (a) IQ scores on the 1988 Cognitive Abilities Test for intelligence, (b) Math Total scores on 1987 Iowa Test of Basic Skills (Iowa percentile), (c) age (as of 1-1-88), and (d) reading level (as of 1-15-88).

Table 2

Table of Groups' Mean Scores

	N	AGE	ITBS MATH TOTAL	READ LVL.	IQ
G1 DISCOVERY	16	9.0 YR.	70 %	3.28	113.6
G2 DIRECT	15	9.26 YR.	70 %	3.16	109.7
G3 CONTROL	16	9.14 YR.	71 %	3.21	112.2

No students had worked with Logo before this experience but some had worked with EZ LOGO, a less complex version for young students by Minnesota Educational Computer Corporation.

Design

The experimental design used in this study was a 3 by 5 factorial design (Ary, Jacobs, & Razavieh, 1985). The three treatments consisted of guided discovery method of Logo instruction, direct method of Logo instruction, and control group with no instruction. The five levels of cognitive style examined were field

dependent (low), level two, level three, level four, and field independent (high).

Procedures

After permission from the administration was received, each student and their parents signed a permission slip to take part in the study. All three classes were group pretested for problem solving skills using the Purdue Elementary Problem Solving Inventory (Feldhusen et al., 1972).

Each student was individually tested for field dependence/independence using the Children Embedded Figures Test (Witkin, Oltman, Raskin, & Karp, 1971). The same researcher administered the examinations to each child.

The instruction time was 45 minutes for a ten week period, meeting once a week. The guided discovery group met on Mondays and the direct instruction group met on Fridays, both from 10:30 to 11:15. The Logo instruction took place in a computer lab with sixteen Apple IIe or IIc computers and a large monitor. The same researcher taught all groups.

The control group continued their normal classroom computer use, involving word processing and drill and practice, taught by the classroom teacher. All three groups were involved with word processing instruction and drill and practice computer use. The control group was taught Logo only after the data had been gathered. The administration requested that all three groups be given Logo instruction during the course of the year.

Apple Logo II, purchased from Logo Computer Systems Incorporated, was the programming language used for both experimental groups. The students each had a computer for their sole use and also had access to a computer in their classroom to work independently outside the Logo instruction period.

Guided Discovery Group

The guided discovery group was taught using Papert's ideas and suggestions from many studies. There was no set curriculum but lessons were designed on a weekly basis to fit the progress and discoveries the students made (see Log, Appendix B). Emphasis was put on the guided part of discovery. Papert and other researchers (Delclos, Littlefield, & Bransford, 1984; Watt & Watt, 1986; Kee Au, Horton, & Ryba, 1987; Dalton, 1986) suggested that guided discovery stresses questioning, facilitating, and guidance by the teacher.

Students were free to discover after new concepts were introduced. Students talked with each other about their programs, processes, and results. The teacher responded to student questions with more probing questions, rather than giving direct answers. Papert's strategy of "ask three before me" to answer student questions was used (Papert, 1984, p. 10). The group discussion at the end of each session was to relate the day's discoveries. A time to share ideas with other classmates was provided each session, either informally or in a large group.

Open-ended lessons were given. For example, the second day, the students were instructed to experiment using right angles or square turns. If a student discovered a particular feature of the

Logo language, the next lesson built on this discovery. Student requests to learn about circles or other concepts, were honored. The information students requested was not given directly but they were questioned to determine a possible path to find the answer.

Direct Instruction Group

The direct instruction section was designed to aid problem solving skills gained through Logo to transfer to other areas. Discussions at the beginning and end of each class were directly led by the instructor to view the turtle or microworld problems as related to real-life problems. The groups were relatively parellel at the beginning and new concepts were introduced at the same time points. So both groups were provided the same essential technical information.

Students were informed of the problem solving steps they would encounter in each day's activities. The steps defined by Feldhusen, Houtz, and Ringenbach (1972) in the Purdue Elementary Problem Solving Inventory were directly taught as transferrable skills with which to solve Logo problems as well as other problems.

Structured activities accompanied lessons to assure mastery of commands and concepts (see Log, Appendix C). Most lessons began with a check for mastery worksheet, including suggested activites for the day. Some Assessing Learning With Logo sheets were used (Nolan & Ryba, 1986).

Direct information was given to this group as they followed a structured sheet of activites for the day. At the end of each session students were pulled together to relate the ideas they

learned to non-computer situation. Questioning techniques were used here, but the emphasis was on how Logo commands and procedures relate to other real-life problems. For example, the problem of giving directions to a person who didn't know the town was related to giving directions to the turtle.

Control Group

The control group had no intervention between pretest of PEPSI and the posttest of PEPSI. There only exposure to computers was word processing instruction and drill and practice, part of the third grade curriculum. They received Logo instruction only after the study was completed, as requested by the Hudson School administration.

Materials

The Purdue Elementary Problem Solving Inventory (PEPSI) was developed by Feldhusen et al. (1972) to assess problem solving ability in children of various ethnic backgrounds in first through sixth grade. This test was used for pretest and posttest. The pretest was given in November and the posttest was given in April after 10 weeks of Logo instruction. The developer, John Feldhusen (personal communication, June, 1987), suggested that the time involved between testing should alleviate any possible test sensitivity problems. Feldhusen et al. (1972) established a reliablity of .79 for the inventory using the Kuder-Richardson formula 20. This is a relatively high rating based on 1.0 as perfect reliability.

This test was chosen because it uses a tape and slides with cartoons concerning real-life situational problems. General problem solving abilities were measured by this real-life situational inventory. Norms for third graders were established by the researcher based on norms established by Feldhusen for second, fourth, and sixth graders.

The Purdue Elementary Problem Solving Inventory identifies twelve problem-solving subskills: (a) Sensing the problem (6 items), (b) Identifying the problem (5 items), (c) Asking questions (6 items), (d) Guessing causes (2 items), (e) Clarification of goal (2 items), (f) Judging if more information is needed (3 items), (g) Analyzing details of the problem and identifying critical elements (3 items), (h) Redefinition--seeing something familiar in a new way (4 items), (i) Seeing implications (6 items), (j) Verification of solutions (4 items), (k) Solving a single solution problem (3 items), and (l) Solving a multiple solution problem (3 items).

The Children Embedded Figures Test (CEFT), a measurement of perceptual field dependence/independence, was administered once to each student individually before the Logo instruction began. The test written by Witkin, Oltman, Raskin, & Karp (1971), follows the same format as the Embedded Figures Test for adults by Witkin et al. (1977). The subject's task on each trial is to locate a previously seen simple figure (cut-out triangle and house shapes) within a larger complex figure.

It assesses field dependence for children ages 5 to 12 in a series of 25 items, each with a hidden shape. The test was

administered by this researcher according to the testing instructions.

There is no time limit as the student searches for the embedded figure. The student scores either 1 or 0. A score of 1 is given only when the first choice is correct. If the student corrects a wrong answer before being shown the cut-out model, full credit is given. A score of 0 is given if the student fails to identify the shape, needs to see the cut-out shape, or gives up. Reliability estimates of the test range from .83 to .90 and relate positively with the Embedded Figures Test by Herman Witkin.

The CEFT manual had no guidelines for determining field dependence/independence levels and the literature was inconsistent. Moore (1985) and Wicker and O'Tuel (1979) divided the possible range of scores into thirds to place Field Independent, Neutral, and Field Dependent. Saarni (1973) ranked test scores for all subjects with resulting distribution divided into thirds.

For this study, the range of scores were divided into five levels of increasing field independence. Scores of 10 and 11 were classified as Low (n = 10); 12, 13, 14 as level two (n = 9), 15 and 16 as level three (n = 9); 17 and 18 as level four (n = 11; and 19 to 25 as High (n = 8).

Statistical Analysis

The statistical tests examined the relationship between field dependence scores and success through method of instruction. The relationship between method instruction and Purdue Elementary Problem Solving Inventory was also analyzed.

A two way analysis of variance was used to find the variance in and between the three groups. The relationship of field independency to gains in performance on the PEPSI test was analyzed by instructional method, gender, and CEFT scores. The .05 level of significance was used.

A two-tailed T-test was performed on all three groups to determine the significance of Logo instruction versus no instruction on problem solving skills. The .05 level of significance was used.

A Pearson correlation matrix was used to determine significant interrelationships of scores of PrePEPSI, PostPEPSI, and CEFT. The .05 level of significance was use.

CHAPTER IV

Results

The purpose of this study was to examine the use of the Logo programming language in the elementary classroom as a vehicle to teach problem solving. The question of guided discovery versus direct instruction methods for Logo and the amount of teacher intervention was researched. Transfer of generalizable problem solving skills to new situations was also assessed.

The perceptual style of field dependence or field independence was examined to determine any relationship between ability to develop problem solving skills through Logo programming and transfer them to real-life situations. The relationship of field dependence/independence to the ability to learn problem solving skills in a guided discovery method versus a direct method of Logo instruction was examined.

Analysis of Data

Two-tailed T-Test

The two-tailed t-test is a statistical procedure that calculates a T value for testing the null hypothesis. The t-ratio shows the significance of observed differences in groups. Since this research was looking for positive or negative coefficients, a two-tailed t-test was used.

Research Question 1. What effect does teaching Logo have on students' problem solving skills versus no Logo instruction?

The pretest of the Purdue Elementary Problem Solving Inventory (Feldhusen et al., 1972) was compared with the posttest. The change in scores was analyzed to determine significance of Logo instruction versus no Logo instruction. This measure of problem solving skills was the vehicle used to identify development in problem solving abilities.

Research Question 2. Which method of Logo instruction, direct or guided discovery, will have a more positive effect of students' general problems solving abilities?

The difference between the pretest and the posttest on the Purdue Elementary Problem Solving Inventory (PEPSI) was used to determine effects of Logo instruction on students' problem solving skills. The mean difference in the guided discovery instruction group was +1.94. The mean difference in the direct instruction group was +2.07. The control group received no treatment. The mean difference in the control group was -.69 (Table 3).

Table 3

Summary Table of the Means and Standard Deviation of PEPSI Score and CEFT of the Groups

Group	N	PrePEPSI Mean	SD	PostPEPSI Mean	SD	CEFT Mean	SD
Guided Disc	16	39.19	5.30	41.13	3.86	15.75	4.01
Control	16	42.75	2.95	42.06	2.74	16.19	3.56
Direct	15	41.13	3.68	43.20	2.34	14.27	4.27

For the purpose of this study, the .05 level of significance was used (Ary, Jacobs, & Razavieh, 1985, p. 423). The T value was significant at the p > .05 level in both Logo instruction groups, the guided discovery and the direct. The guided discovery group had a t-ratio probability of .008 and the direct instruction group had a t-ratio of .000. The t-value of -2.78 in Logo groups shows that the chance of the observed differences in the three groups was 2.78 times greater than would be expected under the null hupothesis (Table 4).

Both Logo treatments groups improved significantly while the control group did not. The presence of Logo instruction was determined valuable to problem solving gains. Teaching Logo in either method significantly changed problem solving skills. Neither instructional group was significantly better than the other.

Table 4

Summary Table of Two-Tailed T-test on Posttest of PEPSI

Group	Pre PEPSI Mean	Post PEPSI Mean	T Value	df	Corre.	2-Tail Prob.
Guided Disc.	39.19	41.13	-2.78	15	.861	.000*
Control	42.75	42.06	.77	15	.224	.404
Direct	41.13	43.20	-2.78	14	.653	.008*

*Significant at p > .05

Pearson Correlation

The Pearson correlation statistical procedure is an index for indicating relationships between two variables. In this study, a matrix of Pearson correlations provides a P value to show interrelationships between age, CEFT (the measure of field independence), pretest of PEPSI, and the post test of PEPSI. The resulting coefficients indicate the direction of the relationships as well as the strength of the relationships.

The scores of all subjects, control and treatment were used for the matrix. A perfect positive correlation coefficient is +1.0. A perfect negative correlation is -1.0. When there is no correlation between variable, the coefficient is 0.0. The stronger the correlation, either positive or negative, it is closer to +1.0 or -1.0.

Field dependent students were predicted to perform better on a measure of problems solving if they had received a direct instruction method of Logo. Field independent students were predicted to perform better after guided discovery instruction of Logo. The Pearson correlation matrix was appropriate statistical approach to establish the strength and direction of any relationships.

Research Question 3. What perceptual orientation, field dependent or field independent, correlates more positively with problem solving skills gained through Logo instruction?

Field dependent students did not differ significantly in problem solving gains from field independent students. Scores on the Children's Embedded Figures Test did correlate significantly with the scores of the PrePEPSI test (p = .24). The CEFT scores did not significantly relate to posttest results (p = -.03). Scores on the PrePEPSI test did correlate significantly (p = .65) with the scores on the Post PEPSI test (Table 5).

Table 5

Summary Table of Pearson Correlation Matrix

	Age		CEFT		PrePEPSI		PostPEPSI	
	P	Sig.	P	Sig.	P	Sig.	P	Sig.
Age	1.000	.000	.02	.436	-.05	.358	-.14	.167
CEFT	-.337	.436	1.00	.000	.24	.049	-.03	.420
PrePEPSI	-.054	.358	.24	.049*	1.00	.000	.65	.000*
PostPEPSI	-.144	.167	-.03	.420	.65	.000*	1.00	.000

Significant at the p > .05 level.

Analysis of Variance

Analysis of variance is a statistical procedure used to test the differences between mean scores. It is based on the rationale that the total variance of all subjects in an experiment can be analyzed into two sources, variance between the groups and variance within the groups. As the variance between groups increases, the F-ratio increases. As variance within the groups increases, the

F-ratio decreases. This procedure was selected because it was predicted that the treatment and the students' field dependence/independence orientation would interact.

The difference between the pretest and the posttest scores of the Purdue Elementary Problem Solving Inventory was used to answer this research question. The mean difference for the guided discovery group was +1.94. The mean difference for the direct instruction group was +2.07. The control group received no treatment during the 10 week instruction period, had a mean difference of -.69 (Table 3).

Research Question 4. Which perceptual orientation, field dependent or field independent, correlates more postively with method of instruction, direct or guided discovery?

There was no significant connection between instructional method and perceptual orientation. The differences in the means of the three groups were not significant enough to say that different treatments caused specific effects. The differences were not significant enough to say that field dependent or field independent orientation provided for greater learning through either instructional treatment (Table 6).

The only significant F ratio was gender. The data analysis showed that the difference between gender problem solving gains was not significant. For the analysis of variance the CEFT scores were grouped: 10, 11 = low; 12, 13, 14 = level 2; 15, 16 = level 3; 17, 18 = level 4; and 19 to 25 = high.

Table 6

Summary Table of Analysis of Variation of Posttest PEPSI by CEFT, Treatment, and Gender

source of Variance	DF	F	significance of F p > .05
Main Effects	10	1.770	.103
CEFT	4	1.131	.357
Treatment	2	.999	.378
Gender	1	.000*	.986

* significant at the p > .05 level

The results of the analysis of variance showed that both Logo instructional groups improved similarly, regardless of the type of instructional method. The instructional methods did not correlate with the scores of field dependence/independence.

CHAPTER V

Summary, Conclusions, and Recommendations

Summary

The purpose of this study was to develop empirical data concerning the use of Logo as a method to improve problem solving skills in students. Logo programming was taught to two different groups, one with a direct instruction method and the other with a guided discovery method. A control group received no Logo instruction treatment. Their only computer exposure was to word processing and drill and practice. The continual debate concerning the value of using Logo as a vehicle to develop problem solving was the impetus for this research. Problem solving skills were evaluated using the Purdue Elementary Problem Solving Inventory. The method of instruction, direct versus guided discovery was also investigated.

Forty-seven third graders took part in this experiment. All three sections were closely comparable by their age, Iowa Test of Basic Skills Math score, reading level, and IQ. The students were also tested using the Children's Embedded Figure Test to determine their level of field dependence/independence. It was predicted that the field independent student would succeed better in the discovery method and the field dependent student would fare better in the guided discovery method. The characteristics of the students were analyzed to determine the best possible setting for Logo instruction.

Students were given the pretest in November of 1987. The Logo treatments were given once a week, for 45 minutes, for a ten week period. There was a one computer to one student ratio. The same researcher taught both treatment groups. The posttest of the Purdue Elementary Problem Solving Inventory was given after the ten week sessions and a lapse of three months. The control group received Logo instruction after all testing was concluded.

Conclusions

The presence of Logo instruction proved to be significant in gains of problem solving skills. Instructional method was not significantly different in development of problem solving skills. Both guided discovery and direct instruction, showed observed significance gains. The control group, with no Logo instruction showed no gains in problem solving skills.

An important finding was the success of the guided discovery method of instruction. As the developer of Logo, Papert describes discovery learning with Logo as the best method of learning problem solving. The discovery method has been contested and questioned by many researchers due to lack of empirical data to support its use (Pea, 1983, 1987; Pea & Kurland, 1984; Tetenbaum & Mulkeen, 1984). The discovery instruction used in this study used a qualified trained teacher in the discovery instruction method. The intervention of teachers using questions, guidance, and suggestions plays a large role in development of problem solving skills.

Another observation from this study was that opportunity for discovery in the direct instruction method was evident.

Observations made during the direct instruction group included some of the same discovery experiences as made during the guided discovery group. Even if there was not specific time set aside to "discover" in the more structured direct instruction method, there were discoveries made. Students who were excited about programming in Logo were asking questions, using the computer in free time, and discovering exciting turtle tricks on their own. This discovery happening on its own, is what Papert discusses as the child finds a reason and a desire to make the turtle do what they want.

Some examples of discoveries made in both groups follow: One student discovered the wrap feature and the news spread as every one wanted to know how to do it on their monitor. Students were looking at each other's monitor with excitement and asking how to do it themselves. In the third guided discovery session, two girls were writing a procedure for a square. The first part of their program was four commands: FD 8 FD 9 FD 6 FD 90. After questioning from the teacher, they discovered that the four forward commands could be combined and stated as FD 23. The emphasis of the discussion between the students and the teacher, was on their discovery of this short cut. They were not told how to type in FD 23 as a quicker way. The look on the students' faces, the light bulb going on, and the excitement with which they returned to their program, is the nebulous "something wonderful happening in classrooms" that Papert and other researchers find so hard to quantify (Cox, 1987, p. 17).

The cognitive orientation of students toward field independence or field dependence does not influence their ability to gain problem

solving skills through Logo. Two different methods of instruction produced no significant difference on scores on the problem solving measure. Perhaps the field independent students can learn and adapt in either a discovery setting or a direct instruction. Their ability to impose structure on their learning and test hypotheses may simply not be inhibited by the direct instruction method.

In both Logo environments, there was opportunity for socially-oriented work and discussion as well as independent work. These opportunities coordinated with student preferences. The field dependent student prefers socially-oriented learning while the field independent student prefers independent work (Witkin et al., 1977). Students who wanted to walk to another computer and discuss with a classmate their programs were allowed to do so in both instruction methods. The student who preferred isolation was free to maintain independent work. Perhaps the flexibility of the Logo environment related successfully with both types of learners.

The direct instruction group was provided with specific goals each class period. This imposed structure with reinforcement was designed to develop the field independent students' problem solving skills. The discovery group was given suggestions and possible problems for each class period. The open-ended aspect of the guided discovery group was designed to supply the environment that the field independent student prefers. Their ability to set their own goals and to self-reinforce was optimized in the guided discovery setting. Once again, the Logo environment itself, may provide a

wide range of opportunities for students of either cognitive style orientation.

The capabilities of Logo to engage students in active learning may be more significant than their field dependence/independence orientation. The immediate feedback of the turtle graphics mode may be important to the cognitive gains of both types of learners.

It is not surprising that the pretest correlated positively with the Posttest, even with the three month time interval between test periods. The students did not see their scores on the pretests nor where answers discussed. They answered similarly on the posttest. Many of the students began with good problem solving skills and continued to enhance them through Logo instruction.

Recommendations

The data showed that the instruction of Logo, by either method, is significant to students' problem solving skills. This merits the implementation of more curriculum planning devoted to Logo instruction. An articulated curriculum of Logo in elementary schools can provide teachers with a vehicle to develop higher level thinking in students. Costa's (1987) warns that it often takes a minimum of two years to see enduring and significant changes observed. A recommendation of a kindergarten through sixth grade exposure and development of Logo programming for students should be researched for long term gains.

Continued instruction with these same subjects and follow up with long term problem solving assessment is recommended. The plan to adminster the Purdue Elementary Problem Solving Inventory at the

end of the subjects fourth grade year, will provide valuable long term assesment. One third of these students will receive direct Logo instruction in fourth grade and one third will receive guided discovery Logo instruction. One section does not receive Logo instruction at all. It is recommended that the PEPSI test or another measure of problem solving be administered to them at the end of their fourth grade year.

Continued observation of the subjects growth in problem solving with attention to their cognitive learning style is recommended. In a longitudinal study, the field dependent and field independent characteristics may be more easily observed. The long term exposure to guided discovery or direct instruction in Logo may develop into significant development of problem solving skills.

A revision of the PEPSI test for more mature elementary students is recommended. More appropriate questions for rural and urban students would eliminate conflicting answers based on environmental experiences. For example, the question of fixing a broken swing with a tire as the most unusual solution is really not that unusual to the rural Iowan. The artwork in the cartoons could be better quality and in color to maintain student interest and clarification of questions. The answer sheet could be revised for simple manipulation by young students. Fourteen pages of three to six answer boxes per page, is difficult for third graders to handle.

Training for teachers to develop their guided discovery teaching methods, including instruction on the cognitive differences of field dependence/independence to allow for individual differences

is recommended. The area of learner characteristics affecting the method of instruction can be researched through identification. As educators develop lesson designs to complement students' learning styles, prescription instruction could produce quality results.

An interesting finding of this study was the attitude of the student about success with Logo programming. A general observation by the researcher found students who discovered concepts and programs by their own discovery, had a higher self esteem and more pride concerning their programs. Some of them even were hiding their programs because they worked so hard to develop a successful design. Others proudly proclaimed how to program a design for the whole class. A measure of the child's self esteem, using direct versus guided discovery instruction, would merit more research.

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Appendix A

Permission Slip

Dear Third Grade Parent;

I am conducting research for my thesis work at U.N.I. It will involve the insruction of Logo, a computer programming language with the three third grade classes. The instruction will take place during the school day and will not interfere with your childs' classroom instruction.

I will be meeting with each section for 10 weeks, one session a week. My goal is to determine the best method of instruction to increase students' problem solving skills.

The students will be pre-tested and post-tested. All results will remain confidential. Your child's participation is voluntary.

If you have any questions about research, you may call the Graduate College, University of Northern Iowa, at 319 273-2748. You may also call me at school, 988-3239.

Please sign the consent form and return to Mrs. Deb Roach before October 1, 1987. Thank you.

Mrs. Deb Roach
Hudson Elementary School
136 S. Washington
Hudson, Iowa 50643

I am aware of the nature and extent of my son/daughters' participation in this project. I acknowledge that I have received a copy of this consent statement.

_____
(signature of parent or guardian)

_____
(student's name)

_____ _____
(signature of researcher) (date)

Appendix B

Lesson Logs

Lesson Log for Guided Discovery Group

Day 1--Introduction to turtle
Basic commands introduced: Fd,Bk,Lt,Rt,Cs
Play turtle: student commands, student as turtle

Day 2--Review command
Twenty minutes to experiment
Break and share with neighbor what is on screen
Group discussion of discoveries:
Wrap feature
Turtle complaints with type errors
Turtle's heading makes a difference, right/left versus up/down
One asked about saving program
One asked about putting commands all on one line

Day 3--Review commands
Mission: try to make something with square corners
Last ten minute discussion:
Draw on paper what they made on screen
ie: building, flag, overlapping diamonds, envelope, 5 square row, stair step

Day 4--Share three commands that you know with a neighbor
Continue experimentation from last time
Midway stop and show it and explain to neighbor
Group discussion:
Two students discovered that Fd 8 Fd 7 Fd 9 together would equal Fd 24
Two students showed the same square grid design and then read their programs. Both were totally different.
One wanted how to know how to fill.
One wanted to know how to save their work.

Day 5--Group discussion of patterns, ask if patterns in their programs
Explained Repeat command to save time
Experiment
Group discussion, shared what they made and how

Day 6--Reviewed patterns and repeat commands
Showed procedure writing To SQ
Worked on squares with repeat command
All were albe to make a square and spin it
Three wanted to know how to change the size of the square so there were shown the editor

Group discussion: one changed the size of square for new designs, one wrote a new procedure for a bigger square, discussed different amounts of turn between squares, ie: SQ rt 10 or SQ rt 30

Day 7--Experiment with procedures and repeats
Group discussion

Day 8--Experiment on continuing ideas from past time
Group discussion:
One made a ladder with repeat command
One tried diagonals and used FILL
One tried to make a circle
One edited each time to make his square bigger
One used fill and works with a white background

Day 9--Check for understanding--all okay on procedure writing
Introduction to circles, they decided to change both the angle and the side to get a circle, it should be smaller than 90 degrees they thought, student play turtle to take small steps and small turns
Group discussion:
showed what spinning square designs they made with a small procedure and a turn

Day 10--Group made 5 guesses about circle procedures and we wrote them on board. Tried changing number of repeats, amount of turn, and amount of forward. One guess worked. As they experimented, one got an octagon, one made a series of growing circles, one worked on a face, one made giant circles that couldn't all fit on the screen, one made a screen full of circles of the same size.
They wanted to print, so all printed one design

Lesson Log for Direct Instruction Group

Day 1--Introduction to Logo as a problem solving learning tool
Students made aware that we were working with a plan to solve problems
Introduction to basic commands:
Fd, Bk, Rt, Lt, Cs
Play turtle

Day 2--Turtle complaint worksheet
Find how many steps across screen and from top to bottom
Sheet take with, real world communication complaint
Work with any design

Day 3--Check coding sheet from Assessing Learning with Logo
Work with square shapes
Make the smallest square, biggest, a square inside a square
Group discussion: How does the turtle relate to the real world? Answers: using a map, drawing, planning building, math

Day 4--Review writing in codes, name other languages
search for patterns in real world, Pe, calendar, music
Introduce repeat command

Day 5--Exploring with Basic turtle command sheet

Day 6--Checking your prediction skills worksheet Commands made the letters F and V with turtle graphics
Type in the commands from the sheet and check prediction
Try working on letters for your name or initial
Explained editing

Day 7--Discussion about problems writing a program to draw their letters
Introduced the first four steps to solving problems:
- Sense a problem
- Identify the problem
- Ask quetions
- Guess causes

Discussion on application to all problems? Logo problems?

Day 8--Review repeat
Handout and review the 12 steps of problem PEPSI
Go over the steps using a flat tire as the problem

Day 9--Repeat worksheet Checking your coding skills (Horton & Ryba)
As a class we wrote repeat commands for:
pushups, three meals a day, school schedule, year calendar

Day 10--Debugging worksheet, first on paper, then try on computer
State the first four problem solving steps in PEPSI

Appendix C

Sample Activity Sheets

The following are examples of structured activities for the Direct instruction group. Permission to use parts of Assessing Learning With Logo by Nolan and Ryba (1986) was received in 1987. The first two activities are from this booklet. The third and fourth examples were designed by the researcher of this study.

Assessing Learning with Logo

Name: _____

Date: _____

Checking Your Coding Skills

Basic Turtle Commands

1. What do each of these commands tell the Turtle to do? Write your answers in the space beside each command.

RIGHT _____

LEFT _____

FORWARD _____

BACK _____

SHOWTURTLE _____

HIDETURTLE _____

CLEARSCREEN _____

PENUP _____

PENDOWN _____

2. This set of commands is written in long form. Write the short form for each command in the right column.

Long Form	Short Form
CLEARSCREEN	_____
FORWARD 50	_____
BACK 25	_____
RIGHT 90	_____
FORWARD 25	_____
LEFT 90	_____
FORWARD 25	_____
BACK 50	_____
PENUP	_____
RIGHT 90	_____
FORWARD 25	_____
LEFT 90	_____
FORWARD 50	_____
PENUP	_____
HOME	_____

Assessing Learning with Logo

Name: _____

Date: _____

Checking Your Prediction Skills

Basic Turtle Commands

1. Draw a picture to show what you think these commands will tell the Turtle to do.

Commands	Draw what you think will happen	Draw what happened
A. CLEARSCREEN RIGHT 45 FORWARD 50 HOME LEFT 45 FORWARD 50 HOME		
B. CLEARSCREEN FORWARD 50 RIGHT 90 FORWARD 25 PENUP HOME PENDOWN FORWARD 25 RIGHT 90 FORWARD 25		

Now, type in the commands to see what happens.

Draw a picture to show "what really happened" in the space next to your first drawing above.

FEEDBACK COMPLAINTS

NAME:_____

2/8/88

Do this:	Feedback complaint:	Fix bug by:
1. Dial a wrong phone number	wrong person answers	Recheck number & redial
2. Call someone is already talking on their phone		
3. Tell someone who is lost to "go this way a few miles."		
4. Make cookies and put in 20 cups of flour instead of 2 cups.		
5. Type an extra 0 while figuring a math problem on a calculator		
6. The medicine is to be taken twice a day and you take it twice a week		
7. When writing a note asking someone to "go write now" and you mean "go right now."		

Roach, D. 1988

DEBUGGING

NAME:_____

3/21/88

1. Decide if there is a problem.
2. Find where there is a problem.
3. Try out some solutions.
4. Fix the problem with the best solution.

This Logo program has been written to draw this shape.

Follow steps 1 - 4 to solve any problem with the program. Cross out a bug and write in the corrected command. You may use the computer to debug.

```
FD 30
BK 30
RT 90
FD 30
LT 90
FD 30
BK 60
RT 90
FD 30
LT 90
FD 30
BK 30
RT 180
FD 30
LT 90
FD 30
BK 30
LT 90
FD 30
FD 30
LT 90
FD 30
```

Roach, D. 1988

Appendix D

Schedule

1987

SEPTEMBER--Received approval from Hudson School Administration
Received cooperation from three third grade teachers

OCTOBER --Received parent consent forms from subjects' parents

OCTOBER TO
JANUARY 15--Tested individual CEFT, one child a day

NOVEMBER 9--Pretested PEPSI with 3 Discovery Group

NOVEMBER 12--Pretested PEPSI with 3 Control Group

NOVEMBER 19--Pretested PEPSI with 3 Direct Group

1988

JANUARY 15
TO MARCH 15--Logo instruction of direct instruction group Mondays
Logo instruction of guided discovery group Fridays

APRIL 11-15--Posttested PEPSI with all three sections

APRIL 15
TO MAY 30--Logo instruction with control group